

Urban household energy use in India: efficiency and policy implications

Manzoor Alam

Institute of Energy and Environmental Studies, Hyderabad, India.

Jayant Sathaye

Lawrence Berkeley National Laboratory, Berkeley, California, USA

Doug Barnes

The World Bank, Washington DC, USA

Biomass-based fuels are being steadily replaced with modern fossil fuels and electricity in cities of developing countries. The latter energy sources are more convenient and efficient to use, and produce less local pollutants. This fuel transition has accompanied economic growth in many cities. Empirical data to substantiate these generalizations are being gathered by researchers. We report on a recent survey of household energy use in the city of Hyderabad, India. The survey reveals that the underlying fuel transition is consistent with that in other developing-country cities. Government policy, however, has favored the rich, because of the inequities in fuel and equipment availability among income groups. We report the major findings of the survey in context of other data for India, and suggest policy changes to redress these inequities. © 1998 Elsevier Science Ltd. All rights reserved

Introduction

Urbanization has become an integral part of the socio-economic growth of developing countries. The levels of urbanization vary across countries and continents, but population growth is much faster in cities than in rural areas due both to higher natural increases and to net migration. Cities tend to be the focal points of economic activity and as Asian countries develop their cities are likely to act as magnets for investments, industrial production and other economic activities. Urban lifestyles are much more similar across countries and continents, by comparison, rural ones tend to differ markedly even within the same country.

In urban and rural areas, energy is needed for the same end-uses – cooking, water heating, space heating in colder climates, lighting and other electricity end-uses, but their energy carriers tend to be very different. The carriers in a rural setting are determined by the local availability of resources; while in a city a wider selection of fuels and equipment is available for use.

Of all sectors, the household sector experiences the most pronounced changes in its patterns of fuel use over

time. Typically a household may shift from using biomass, to kerosene, LPG and finally to electricity for specialized cooking. On the other hand, it may shift from biomass to electricity for water heating. (Sathaye and Taylor, 1991). This shift phenomenon is often referred to as a ‘fuel transition’ from traditional (biomass-based) to modern household fuels. Past studies consistently indicate a strong correlation between household income levels and the types and amounts of fuel used for cooking (Cecelski *et al.*, 1979; Leach, 1988; Reddy, 1990). Based on this observation, researchers have developed the notion of a “fuel-income ladder” to explain the shift to more convenient and higher-quality fuels as household incomes pass certain thresholds (Reddy and Reddy, 1994).

Household fuel transitions often accompany changes in economic activity and lifestyles, and are a central focus of national and state government policy. The primary goal of government intervention in household fuel markets is to improve the availability of modern fuels at affordable prices. Government intervention usually takes the form of subsidies for fuels and electricity, and rationing of scarce fuels. The relative costs of using fuels, however, do not consistently appear to constrain

household fuel choices. Various studies have concluded that many poor households actually pay more for their fuels, on an energy-content basis, than do higher-income households (Bhatia, 1988).

This paper reports on the findings and policy implications arising from a household energy survey of the city of Hyderabad, India. The purpose of the survey was to assist the government in establishing more targeted policies for the provision of energy services in large metropolises and to validate the transition related to the supply and demand of household fuels for a large Indian city.

Background on Hyderabad

Hyderabad, with a population of five million, ranks sixth among the 16 India metropolises with a population exceeding one million. It is one of the historic cities of India founded in 1591. Its modern phase of development commenced in 1956, when it was declared the capital of the state of Andhra Pradesh. The population of Hyderabad has grown rapidly from 1.25 million in 1961 to 4.74 million in 1991, a 279% increase in 30 years at an annual rate of 4.4%, which has increased steadily, and averaged 7.2% between 1981 and 1991. The population growth has been accompanied by an increase in built-up area, which has more than doubled since 1971.

Hyderabad economy appears stagnant and over 40% of the population lies in the low-income brackets. The literacy level is only 76% and most of the literates are not educated beyond the high school level. The size of the household is unusually large (6.5 persons per household) for a metropolitan settlement and has not changed much over the last three decades. The dependency ratio is high with one earner for every four non-earners on the average in a household.

Methods

In order to validate the transition related to the supply and demand of household fuels for a large Indian city, we conducted an in-depth energy survey of 3000 households and small commercial establishments in Hyderabad, India. The survey was conducted through a stratified random sampling of 2000 households in the municipal area, and another 800 in the suburbs. The size of the sample was 0.38% of the total number of 1991 households in Hyderabad. Because earlier energy surveys were carried out in 1966 and 1982 in Hyderabad, this work generated information on long-term household energy use trends (Alam, 1967; Alam *et al.*, 1983). The survey specifically examines issues related to fuel choice, household income, urban scale, and the energy-decision making process. The research examined the adoption of modern fuels for cooking, water heating, and the penetration of electricity and electric appliances in relation to the socioeconomic

characteristics and locations of households. It focused particularly on energy use in low-income households (slum dwellers), and examined factors that serve to reduce the poor households' access to fuels and electricity.

Key findings of the survey

Hyderabad households have witnessed dramatic increases in modern fuel use in recent years. Changing patterns of household activity and livelihood underlie this growth. Biomass fuels, until recently a dominant household energy source in Hyderabad, play only a limited role in current household activities. Even the dominance of kerosene appears to be diminishing as fuel-wood-using households opt for LPG over kerosene. The survey reveals that this increased reliance on modern fuels arises from a preference among consumers for more convenient and readily available fuels. Government policies have played a key role in spurring this transition through subsidized prices and the controlled availability of kerosene and LPG. These policies have also hurt the poor and reduced the overall efficiency of household fuel use in India.

Establishing household energy use patterns, requires a thorough understanding of the socio-economic characteristics of the surveyed households. The survey included data on income levels, household sizes, and education levels. These characteristics explain why households choose certain fuels, why they use certain amounts of electricity, and why they purchase certain types of appliances.

Household income

The economy of Hyderabad has had a very skewed development with extremely uneven distribution of income. This is borne out by the fact that about 43% of the population is in the two lowest income groups. There is excessive concentration of wealth in the highest income group, who constitute 6% of the population. Average household income in Hyderabad was surveyed to be Rs. 3885 (US\$110 @ Rs. 34 = 1 US\$) per month. The survey data was stratified by ten income per capita categories, which were aggregated into five income groups. Household income varied almost six-fold from Rs. 1455 to Rs. 8184 per month across income groups.

The main finding regarding income growth is that household income in 1994 was higher compared to that in 1967, but significantly lower in real terms compared to 1982 (Table 1). Monthly income (in 1982 prices) declined from Rs. 382 per household in 1982 to Rs. 313 in 1994. The decline in real income is probably a combined effect of the lowering of state income for 1994 and strong inflation between 1982–1994.

The lower income also has been accompanied by a worsened income distribution since 1982. The lowest

Table 1 Changes in Hyderabad household income

Year	Income per household (Rs. per month)	Income per capita (Rs. per month)
1967	187	30
1982	382	62
1994	313	47

Note: Deflators used to calculate income at 1982 price levels:

Consumer price index for industrial workers

Consumer price index for urban non-manual employees.

two of the five income groups account for about 43% of the population. Their real income has decreased by almost half from the income levels of 1982. As a consequence, one fourth of the city's population lives below the poverty level of Rs. 264 per capita per month. On the other hand, the real per capita income of the two uppermost income groups increased, by 82% for the top group and 20% for the next one.

Fuel choice

Much of the energy used by Hyderabad households is mainly channeled towards two end uses: cooking and water heating, and to a lesser extent for space cooling, especially during the hot dry summer months. Space heating is not important because the climate is hot with little variability, and an occasional need is satisfied by short-term use of electric heaters. Two fuel transitions, which occur simultaneously, characterize the choice of cooking fuels in Hyderabad households: (1) replacement of biomass and solid fuels with LPG and (2) kerosene with LPG. A third transition, that from biomass to kerosene, which usually occurs at low-income levels and has been observed in earlier surveys (Sathaye and Tyler 1991), is no longer evident in Hyderabad. About 17% of the households are involved in the direct transition from fuelwood to LPG, which occurs at a low monthly income per capita of about Rs. 250. Various factors affect the speed at which these transitions occur: income levels, the availability of fuels, government policies, cuisine, and household activity patterns. With the liberalization of the economy, the availability of LPG has considerably increased which in turn has helped speed the transition to this fuel.

According to the survey results, household fuelwood use declined drastically from a previously high level of 67 kg per capita in 1982 to low or insignificant levels, 14 kg per capita in 1994 (Table 2). The reduced use of fuelwood was offset by the increased use of both LPG and kerosene. Kerosene use increased 20% and reached 23 liters per capita by 1994, and LPG use increased 15% and reached 15 kg per capita (Table 2). Because of the increased use of LPG and kerosene, whose efficiency of use is several-fold that of fuelwood, the input energy consumption for cooking declined from 29 kgoe per household (hh) per month in 1982 to 22 in 1994. The

Table 2 Average fuel consumption per capita by type, Hyderabad

Fuels	1982	1994
Fuelwood (kg)	67	14
Kerosene (liters)	19	23
LPG (kg)	13	15

corresponding output energy consumption increased only marginally, from 9.2 kgoe per hh per month to 9.5 during this period.

Our survey data show that the decline in household fuelwood consumption is offset by a corresponding rise in its use in the non-household sector, which includes commercial establishments, crematoria and wedding halls, and small or tiny scale industries. In these applications, fuelwood is used in bulk quantities in the open air, where fire control is easier and smoke is quickly dissipated.

Electricity consumption

Electricity demand has increased rapidly in Hyderabad in recent years. Higher appliance saturations and more intensive lighting, despite the decrease in household income, have spurred this growth. The incomes of the top two income groups have increased since 1982, however, which coupled with a drop in appliance prices may explain this seeming paradox. Electricity is available to all households in Hyderabad, but it is subject to frequent load shedding, black outs, and voltage fluctuations. The survey revealed that over 30 space illuminating and conditioning, entertainment, water heating and kitchen gadgets and appliances are in use in Hyderabad households. The saturation rate of appliances is similar to that found in another Indian city, Pune (Kulkarni *et al*, 1994), although the water heater saturation is lower.

Electricity represents over one fourth of the total energy consumed in the household sector. The rich consume far larger quantum of electrical energy than the poor. The average monthly per household and per capita consumption of electricity is only 90 and 15 kWh, respectively. The consumption level of the rich and the poor households varies widely. Monthly consumption ranges from 180 and 41 kWh per household and per capita in the highest income group to 57 and 7 kWh, respectively in the lowest income group.

Energy pricing

LPG, kerosene, coal, and biomass in various forms constitute the primary fuels used by the Hyderabad households. Coal use is small in households but significant in small commercial establishments. The availability and prices of each fuel vary across the surveyed households. Subsidized kerosene is available through ration shops at a price of Rs. 3 per liter. The average price paid by

a Hyderabad household was surveyed to be Rs. 3.46, indicating that households purchase some proportion of the kerosene in the open market. The survey also revealed that the lowest-income group pays the highest average price at Rs. 3.6 per liter, implying that they purchase about a quarter of their kerosene on the open market. In contrast, households in the highest-income group pay an average price of Rs. 3.33 per liter while purchasing about 12% of their kerosene in the open market.

LPG is sold at a subsidized price of Rs. 7.57/kg. It is available on the open market at a much higher price of about Rs. 13/kg. The price and supply of fuelwood is not regulated and its surveyed price was Rs. 1.1/kg. Table 3 shows the prices of each of the three cooking fuels. LPG is clearly the most expensive in terms of its price per unit of input energy.

Of the three fuels, kerosene and LPG, prices are subsidized and fuelwood reflects its market price, which therefore turns out to be the most expensive fuel, when combustion efficiency is accounted for (Table 3, column 4). If subsidies are eliminated, the prices of kerosene and LPG, adjusted for combustion efficiency, are almost the same and are close to the market price of fuelwood (Table 3, column 5).

The average price of electricity paid by surveyed households was Rs. 1.10/kWh. It varies only slightly from Rs. 1.08 to Rs. 1.15 from the lowest to the highest income group. The cost of supply to Hyderabad households is estimated to be Rs. 1.27/kWh, which amounts to a subsidy of Rs. 0.17/kWh.

Energy expenditure patterns

The average household monthly expenditure on all sources of energy is Rs. 211, and varies from Rs. 323 in the highest income group to Rs. 165 in the lowest one. As a percentage of household income, however, the poorest group has to allocate 14% of its income for purchasing energy, while the richest allocates only 3% for the same purpose. Households spend almost half their energy expenditure on electricity. On an average, households spend 44% of their energy expenditure for electricity, 27% for LPG and 23% for kerosene. The expenditure on fuelwood is a mere 5%. The share of expenditure on the three fuels varies with income. While the lower income groups spend more on fuelwood (23%) and kerosene

(66%), the higher income groups spend nearly 92% on LPG. Across income groups, the expenditure on electricity remains fairly high: the rich allocate 60% and the poor 34% of their energy expenditure for electricity.

Policy implications

The Indian government administers the supply of kerosene, LPG and coal. It limits the amount of kerosene available at subsidized prices. Consumers with legal residences may purchase subsidized kerosene using ration cards provided to them by the government. Because the government does not give ration cards to households in illegal squatter settlements, these low-income consumers must purchase kerosene at higher prices in the open market or use alternate fuels such as fuelwood or charcoal. Government restrictions used to limit each household to one subsidized LPG cylinder in the past, which when emptied could be exchanged for another. In the 1990s, LPG supply has been liberalized and the fuel has become available on the open market at prices that are nearly double those of subsidized supply. The fuelwood market in Hyderabad, however, is well structured and highly organized; it operates freely and efficiently without any direct government intervention.

Effects of existing policies

Despite the good intentions of policy-makers, the supply of energy to Hyderabad consumers remains inequitable where the poor do not have as good an access to subsidized fuels as the rich. The fuel subsidies do not appear to be needed since they primarily benefit the well-to-do. The electricity supply is unreliable and generates inadequate revenue to finance future improvements to the APSEB system. We explore these issues in more depth below.

Public distribution system not well directed to help the poor Although the ration card system is intended to make kerosene more affordable and available to the poor, it is not very well targeted. It benefits more the wealthy- and middle-class households. The poorest households without addresses cannot gain access to ration cards, and pay much higher market prices for kerosene, or use inefficient and consequently very expensive fuelwood for cooking. In addition, the ration shops

Table 3 Fuel prices adjusted for combustion efficiency

Fuels	Subsidized Prices (Rs./unit)	Subsidized Prices (Rs./kgoe of input energy)	Subsidized Prices (Rs./kgoe of useful energy) Col. 4	Market Prices (Rs./kgoe of useful energy) Col. 5
Fuelwood*	1.1/kg	2.90	19.4	19.4
Kerosene	3.0/l	3.7	10.5	19.2
LPG	7.6/kg	7.14	11.9	20.0

Note: All prices are market prices. Fuelwood is not subsidized.

get kerosene only periodically and in limited quantities, so the supply routinely runs out before the next allotment, leaving the poor to either purchase open market kerosene or use fuel wood.

Electricity supply under increasing strain Electricity supply to Hyderabad city, and to the state of Andhra Pradesh, is provided by the Andhra Pradesh State Electricity Board (APSEB). It generates, transmits and distributes electricity to urban and rural areas of the state. As a policy of the state government, aided by the national government, the APSEB supplies power to rural agricultural customers at highly subsidized rates. The loss in revenue is made up largely by subsidies from the national government, and in part by higher rates for industrial and commercial customers. Electricity supply to households is subsidized at a surveyed estimate of Rs. 0.17/kWh. In recent years, the APSEB, along with other SEBs, is under increasing financial strain as it is pressured to provide more service with less revenue. In Metropolitan Hyderabad alone the subsidy on electricity amounts to Rs.150 million annually. The large subsidies coming to the SEB mean that it is more concerned with meeting government targets regarding the number of villages electrified as opposed to providing quality service to customers. The consequence is that public opinion regards the SEB is extremely low. Focus group interviews of middle-class and higher-income households reveal support for reforming and liberalizing the distribution of electricity, even if it meant higher prices. There was not a similar level of support from the poor, so special consideration needs to be given to dealing with their problems.

Subsidy on energy The markets for energy in urban Hyderabad are influenced extensively by government policies that provide household fuel subsidies. The difference between the market price and the administered price of a fuel has been assumed to be the amount of subsidy on that fuel. We estimate that LPG, kerosene and electricity are subsidized to the extent of Rs. 5/kg (Rs. 4.6/kgoe), Rs. 2.5/l (Rs. 2.4/kgoe) and Rs. 0.17/kWh, respectively. Taking into consideration the household consumption of each of these energy sources, the subsidies in urban Hyderabad are massive, over Rs.800 million per annum, and are likely to grow as more people switch to "modern fuels". These subsidies are meant to help the poor, but the majority of the subsidies end up in middle- and upper-class households, who can afford to pay market rates for fuels. Likewise, policies to limit imports of fuels create periodic local scarcities. In scarcity, it is the poor who are last to gain access to the fuel, as evidenced by the fact that they had limited access to kerosene until LPG became more widely available for higher-income households. Restricting the subsidy to the low-income target groups would save the government a significant sum of Rs. 573 million annually.

Good impact of forest policy Our survey included an assessment of the vegetation cover in areas surrounding Hyderabad. Both aerial maps and ground truthing was done to ascertain the extent of the ground cover. The analysis of these data showed that because of (1) significant transition away from wood, (2) forestry policies that stress conservation of forests and (3) changing land use patterns, deforestation in the Hyderabad region has slowed considerably. This is very good news, and existing land-use and forestry policies should be strengthened to maintain this healthy, desirable and environment friendly trend.

Policies to improve energy markets

Accessibility of LPG and kerosene should be enhanced. The policies to open up the petroleum markets for LPG and kerosene in urban households should be continued and supported. The availability of kerosene at world market prices has helped the poor gain access to kerosene, a fuel preferred over wood. In addition, the increased import of LPG has meant that the market for this product has expanded among the middle and higher income consumers. The survey finds that the middle class and rich appreciate the convenience of LPG, and will continue to use it even if subsidies are removed altogether and all LPG is priced at open market levels. The switch to LPG. has had the benefit of freeing up the subsidized kerosene for the urban poor. Thus, the general recommendation is to continue to liberalize imports and to allow price competition of kerosene and LPG at competitive world market prices.

Price of electricity should be raised and the APSEB made financially viable. Middle- and higher-income households are willing to pay more for an assured and reliable electricity supply. Raising electricity prices would help the SEB become financially viable. However, this cannot be done on an ad hoc basis, without assurance that service for all sections of society will be improved. It is clear that the public is skeptical that this can be achieved with the existing distribution system and management. An alternative would be allow electricity distribution to be taken over by private companies, who would eliminate illegal connections and increase bill collections.

Fuelwood trade based on market principles functioning efficiently. The fuelwood trade in Hyderabad is already based on market principles and this should not be changed. The forestry department should continue programs that encourage farmers to grow (and harvest) trees on their own farms, since this is the main source of fuelwood for Hyderabad city. Since commercial enterprises are increasingly using wood, it is recommended that the coal subsidy and allocation system be eliminated and coal distribution should be based on market principles.

Policies to help the process of fuel transition among the urban poor

The subsidies that are currently given across the board to all households in urban Hyderabad can be reduced and still benefit the poor urban households. Although the targeting of these subsidies can be a problem, the following recommendations can be of more direct benefit to the poor than the current policies.

The poor can be targeted effectively through lifeline rates for electricity. The reason for this is that the poor use very little electricity. A lifeline rate can be designed based on the household load compared to their income. The findings of the survey are that a lifeline rate of 50 kWh per month would assist the poorest 23% of the households, who have problems paying for electricity. In addition a policy to keep charges for new connections for minimal service very low would be efficient, if it is combined with strict enforcement and policing of illegal connections. A grace period of one billing period should be given before disconnection due to non-payment of bills. The combination of these policies would not constitute a burden on the APSEB and would be equitable.

For LPG, the poor and lower middle class households can be effectively targeted through making initial LPG service more affordable. This could be accomplished through the distribution of LPG in smaller bottles and by incorporating the costs of initial connection fees (bottle and stove) in the monthly bill. This credit could be given for one year, or it could be incorporated into the price of LPG. Retailing the LPG in smaller bottles would cost slightly more than LPG in standard bottles, however, the unit price of LPG in both types of bottles should be the same, in order to avoid leakage from one to the other.

The policy for kerosene is more complicated. In view of the existing level of poverty in the city, subsidy for kerosene ought to be retained to benefit the poor. Under the existing policy, the middle class and the rich are benefiting the most from the subsidy on kerosene; the poor are not able to get from ration shops the quantity of kerosene they need when they need it. It has been observed therefore that it is mostly the poor who purchase kerosene from the open market to fulfill their requirements. In view of this it is recommended that the sale of kerosene through the ration shops for the rich and middle income groups (pink card holders in AP) be totally stopped and only the target group (white card holders) should be entitled to avail of this facility. Simultaneously the sale of kerosene through private retail outlets be encouraged from where the middle and upper income groups may be able to purchase their requirement of kerosene.

An alternate approach would be to halt the sale of kerosene through the ration shops. All sales of kerosene should be made through the retail markets. Small distributors of the fuel should be encouraged, and a coupon should be issued only to poor ration card holders that

will entitle them to purchase kerosene from a retailer at a subsidized price. The consequence of this policy would be to more directly target the poor with the kerosene subsidy. It would also open up the market of the fuel and would simultaneously discourage diversion of subsidized kerosene to other sectors.

The poorest of the poor are still using fuelwood for cooking. Improved stove programs would be an effective policy to help the poor since it would reduce their cash outlay for fuels.

Conclusions

The household sector in developing-country cities has witnessed the most pronounced changes in its patterns of fuel use. Our survey of 3000 households in Hyderabad, India, highlights that despite the city's poverty and weak economic base, the sector has reached an advanced stage of energy transition, and the share of fuelwood in total energy consumption is much lower than before. There is a keen desire among the low income groups to shift to LPG, which is distinctly preferred over other fuels for cooking. Policies that help remove the barrier of high first cost of obtaining LPG will speed this transition.

Energy supplies such as LPG, kerosene, and electricity are highly subsidized. Although the poor constitute the target group, it is the rich who benefit the most from the subsidies. It is mostly the poor who do not have the ration cards and therefore purchase kerosene at market prices. In view of this, subsidies on commercial fuels do not appear to be justified.

Electricity constitutes almost half the household energy expenditure, with its share being greater in higher-income households. The saturation of electric appliances has risen since the earlier surveys despite a decline in household income. This may be due to both lower prices for some of the appliances, and a change in tastes whereby expenditure on entertainment and comfort is valued more than on other items. Despite the growing importance of electricity to households, its supply is the most erratic among all the major energy sources. Brownouts are frequent and supply during the dry season is limited to a few hours a day, when it is most needed. Policies ranging from higher charges, privatization of distribution, and the use of more efficient appliances and lighting are needed to ensure adequate supply in the future, which will require the political and organizational will to enforce appropriate policy measures that has been lacking thus far.

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